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ABSTRACT

It has been acknowledged that the federal government has a responsibility to provide significant support for the nation's basic research whereas the role for support of technology is less understood. This report concerns a study on the determination of the appropriate role of the federal government in technology development. Currently the federal government's principal roles in technology development are the funding of basic research and the procurement of advanced strategic technology. The witnesses at this hearing were two college professors and two industry executives. Major topics addressed in the hearing included: (1) a summary of past technological concerns; (2) organization and functions of the federal government's research and development program; (3) the place of university research and development in a competitive industrial environment; and (4) factors currently effecting private industry. Included is a list of the members of the Committee on Science, Space, and Technology, and the Technology Policy Task Force. (MVL)

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TECHNOLOGY POLICY TASK FORCE HEARING SUMMARY

THE TECHNICAL ENTERPRISE FOR COMPUTERS, COMMUNICATIONS, AND MANUFACTURING IN THE 21ST CENTURY

REPORT

PREPARED FOR THE

TECHNOLOGY POLICY TASK FORCE

TRANSMITTED TO THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

FIRST SESSION

Serial F

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COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

TECHNOLOGY POLICY TASK FORCE

HEARING SUMMARY

ON

THE TECHNICAL ENTERPRISE FOR COMPUTERS, COMMUNICATIONS AND MANUFACTURING IN THE 21ST CENTURY

June 25, 1987

Prepared by

Kevin Kennedy
Principal Investigator, Technology Policy Task Force

I. INTRODUCTION

On June 25, 1987, the Technology Policy Task Force, Committee on Science, Space, and Technology of the House of Representatives, voted to accept its agenda, entitled, "A Study of U.S. Technology Policy." As discussed in the agenda, the determination of the appropriate role of the Federal Government in technology development is a central concern of the Task Force. Today, it is acknowledged and accepted that the Federal Government has a responsibility to provide significant support for the nation's basic research. However, the role for Federal Government support of technology is less well understood. At this time, the Federal Government's principal roles in technology development are twofold:

1. funding of basic research; and
2. procurement of advanced strategic technology, e.g., as in aeronautics, energy, and defense systems.

The sufficiency of this support in light of U.S. competitiveness concerns has and is being debated. The President's Commission on Competitiveness emphasized the need for the Federal Government to promote and nurture an environment for technology development; including monetary policies, and policies for trade and education. Furthermore, the success of foreign countries, such as Japan, Germany, and France, have materially benefited from national support of key industries.

These relationships have included nationalized industries, government regulated monopolies and government assisted/subsidized corporations. Examples of these relationships include the Japanese manufacturing/semiconductor industries and French nuclear energy/telecommunications. These relationships have enabled some countries to attain technological leadership in specific areas.

For these reasons, on June 25, the Technology Policy Task Force held one of several hearings aimed at determining the appropriate role of the Federal Government in support of technology. The task force chose to study the framework of linkages among the Universities, research centers, government laboratories, and private industry, defining the U.S. technological enterprise. Furthermore, the task force felt that it was imperative to review policies as they impact specific industries.

For this reason, the task force identified two technologies, i.e. Communications and Computers, essential to enhancing productivity in both the manufacturing and services sectors. These technologies provided a vehicle for the review of potential policy suggestions.

In assessing the appropriate role of the Federal Government in support of technology development, the task force focused on several rallying concerns, including:

1. What can the U.S. learn from the successes of our foreign competitors?

2. How will the U.S. technological infrastructure accomplish the goal of improved manufacturing and realize the full potential of communications and computer technologies?

3. What are the roles of the universities, engineering research centers, consortia, government laboratories, professional societies and private business within the technological enterprise?

4. What barriers exist to the realization of the fruits of communications, computer, and manufacturing technologies?

II. SUMMARY OF PANEL'S CONCLUSIONS AND RECOMMENDATIONS

The witnesses discussed a number of reasons for the competitive decline in U.S. industry. These reasons included:

- Loss of a captive U.S. market as foreign products began capturing an ever increasing percentage of sales.

- Foreign scientists and engineers became just as competent as U.S. scientists and engineers.

- Transfer of technical information was communicated rapidly to other nations for use in their industries.

. "Spinoffs" from defense research and development to the commercial sector declined.

A. GOVERNMENT POLICY

The witnesses advised the Technology Policy Task Force Members on government policy with such comments as: "What the Congress can do is in certain circumstances to alter the environment within which Americans make decisions."

There were numerous comments concerning Federal Government policies to provide a proper industrial environment with statements such as:

> "Any such policy, it seems to me, has to satisfy two conditions. First, it has to be technologically realistic, and it must be able to coordinate all of our national programs more closely in order to make the best uses of the limited resources which are available such as our foreign competitors are doing."

Other testimony offered:

> "Here we have a government which is spending some $67 billion a year in R&D and is leveraging the other $70 billion of private R&D through the government's regulatory actions and behavior in the marketplace. Yet for the last two Administrations, this is not a political party label failing, both the

last two Presidents, that is, Mr. Reagan and Mr. Carter, didn't get around to appointing a science advisor and a director of OSTP until the middle of the spring, after every other job had been picked, after the White House staff was completely locked up. Hence, there was no bargaining power available for the candidate to negotiate with the Chief of Staff or with the President about what his relationships might be with White House offices, with OMB and with the cabinet offices."

"It seems to me that if we had a strong OSTP and they had the authority to direct the Department of Energy to deploy ten percent of the budget of those national laboratories on a problem that the National Science Advisor and the President agree is urgent, that they be able to deploy that manpower subject again to coming back to the Congress to validate the project they have undertaken through their legislative process and appropriations process which, as you well know, takes a couple of years to get into and back out of again."

Another comment was: "The most important thing to happen is for the Executive Office of the President to take seriously their management responsibilities for R&D."

There was a note of caution, however. The Task Force should avoid recommending INDUSTRIAL POLICY. The comment was: "The policy must not

put Federal agency officials in the position of second guessing business judgements that are best made in a highly decentralized competitive environment responsive to fast changing competition and market conditions."

The subject of tax policy was then discussed. One witness asked:

> "Why don't we tax capital gains at normal income rates for all capital gains made over a period of less than six months and why don't we not tax capital gains at all for capital that is held five years with a sliding scale in between."

> Chairman MacKay pursued this concept by asking: "Why don't we have a surtax on the quick in and out and then a normal tax at the six months level and then tapered down to nothing?"

Congressman Brown also expressed concern over the value of the R&D tax credits and brought up the matter of a permanent investment package, the R&D tax credit, and revamping the long term investment or capital gains situation. "I have no evidence that either one of these has done a damn thing to improve our situation. Have you any indications that it has?"

The response was, "I couldn't agree with you more. The issue here is not particularly just the technology issue but it is the linkage to the economic system. I am not sure that I know the answer. I know

that it did affect our investments, losing investment tax credits on capital and it affected our ability to modernize as fast as we had been."

B. RESEARCH AND DEVELOPMENT SPONSORED BY THE FEDERAL GOVERNMENT

All of the witnesses concurred with the thesis that U.S. national R&D programs require greater coordination in order to make the best use of our limited resources. The witnesses also suggested that the lead in this effort should rest with the Executive Branch. Specifically, a stronger presence by the OSTP could facilitate coordination among agencies, the Council of Economic Advisors, and industry. Federal Government sponsored research and development should be based on direction from industry on a sector-by-sector basis.

However, the practice of federal support of only basic research is very limited and precludes important research in application related technologies. Research investments in application related technologies are of great importance to the national interest.

Chairman Buddy MacKay mentioned that,

"We are about to get into a situation where the amount of money available for science and technology and basic research and development in government is going to be very, very limited. We are not going to have the luxury of deciding we want to do a super collider without figuring out where the money is coming from."

"It is going to get to be zero sum. We are going to have to, in order to do something else, cut out something. Can we afford to continue the luxury of national labs scattered all over everywhere, ...some of whom seem to have outgrown their existing or original mandate, some of whom are engaged in fine public sector entrepreneurial activity of getting out and looking for something to do that has money attached to it?"

The question is one that needs a timely answer and further review of national laboratory and mission agency programs relative to an overall national policy is clearly needed. The answer will depend largely on information received from industry.

Two witnesses noted an important moral in the success of the government's extensive role in agriculture was that, "the farmers asked for it."

C. HUMAN RESOURCES

The need for continually upgrading our education system, especially university programs for manufacturing and the establishment of manufacturing as a national priority were found to be essential by the entire panel.

Congressman Packard asked, "In our institutions, in our universities, do we have courses in our curriculums specifically designed to

instruct people or students in manufacturing, in product development. I know we do in marketing, but do we in product development?" The response was that the level of joint engineering and business training was not sufficient.

One witness offered,

"It is my belief that there is much less interaction and joint work and joint training between American engineering schools and American business schools than there ought to be. In most campuses that I know about, these are two shops on their own bottom and there is not much in the way of training of young engineers to become managers. Many of them, the best of them, soon will become [managers]. On the other hand, the business school training often and in most cases does not dip into giving those students an appreciation of technology or technical change or the management of the research function or the interaction between research and manufacturing that it ought to."

Another witness added,

"I think there is an unsatisfactory level of information diffusion between the knowledge generating sector in our society and a very large group of those who most need it; namely, the firms that are smaller than a billion dollars a year in gross sales which is roughly the level at which you do or don't have a corporate research laboratory." He also stated that "the fruits of the research do not receive the requisite

support from federal science agencies in the areas of: "automated design for manufacturability; manufacturing systems engineering; quality testing and process control; materials handling and distribution; and information systems support for balancing organizational control and efficiency with the decentralized creative decision making."

However, he also noted:

"...that most downstream engineering evidences a mixture of work, some of which is very narrow and application specific and some of which is very general and can be widely shared."

D. RECOMMENDATIONS

While it was much too early in the course of the Technology Policy Task Force study to recommend or even suggest policy, several subjects were viewed worthy of further study.

1. Further review of the national laboratory and mission agencies research and development practices. This work to be done with consideration to how the Federal Government should try to choose technologies which compliment private sector products and technologies.

2. Investigation of the costs of factory renewal. U.S. manufacturing strengths lie in its technology base,

educational system and software capability. The application of U.S. computer and software technology will provide the greatest leverage. The work force is competitive. But industry has had difficulty in applying the appropriate technology, in part, due to the extensive costs of factory renewal. The question is why should U.S. costs be any greater than other nations when the technology and methods are new to everyone?

3. Other areas for investigation were noted.

-- Determining a way to elevate product development and manufacturing capabilities as national objectives.

-- Determine the need to decrease the cost of capital for projects that would strengthen the U.S. industrial base.

-- Determine a way to enhance education in a spectrum of technologies at several levels of complexity.

III. LIST OF WITNESSES AT HEARING

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IV. MAJOR ISSUES DISCUSSED IN THE HEARING

A. HISTORICAL PERSPECTIVES

The June 25, 1987 hearing began with historical notes on U.S. technological development. Dr. Richard Nelson observed U.S. technological prowess as far back as the late 19th century, citing examples such as ship design and interchangeable parts manufacture. He noted that this was an era in which "mechanical savy rather than advanced schooling" mattered. Furthermore, "The principal government contribution was the prevention of the rise of guilds which were blocking technical advance on the Continent and hindering it even in England."

Dr. Nelson also underscored the importance of public funding of our university system. First, he noted that by the late 19th century "the scientific fields of chemistry and physics had become sufficiently powerful that training in these had become virtually essential if one were to be an effective inventor." The acceptance by U.S. and German universities of the basic and applied sciences as a part of the curriculum, provided "industry with the trained scientists and engineers that were required for competence in the new chemical and electrical industries." The supply of college trained professionals in concert with" the vast U.S. common market in an era where international trade was constrained" were important to the success of the U.S. Later, antitrust legislation helped to assure competition among technologically competent firms."

After World War II, the government took on responsibility for the funding of the university basic research system in the U.S. Dr. Nelson noted two additional observations in the post World War II era:
"Students trained under this improved and expanded system fueled the corporate R&D enterprise in that era where training in the basic sciences and technology were even more important than earlier to industrial R&D.

The U.S. also benefited during this period greatly from our massive defense research and development program in an era where several key technologies demanded by the military also had major civilian applications."

Dr. Nelson mentioned that among the causes of competitive decline were: an open world trade system that diminished U.S. manufacturers advantage; the international nature of technology; the catching up by other nations with U.S. scientific and technical training; and diminished U.S. military spinoffs.

All of the witnesses concurred with Dr. Nelson's view that "government policies that are likely to be effective and politically acceptable undoubtedly differ significantly from industry to industry." Dr. Nelson noted that the forms and extent of government support varied significantly between agriculture, health related products and electronics.

Both Dr. Nelson and Dr. Branscomb, noted an important moral in the success of the governments extensive role in agriculture was that, "the farmers asked for it."

Finally, Dr. Nelson urged that the Task Force be mindful of "What is special about present times that calls for significant reconsideration of what government is doing?"

Based on the historical perspective presented at this hearing, the Task Force found that among the causes of the competitive decline of many U.S. industries were:

- loss of U.S. advantage as its large domestic market place became international;
- scientific and engineering talent in foreign countries has caught up with that of the U.S. in many disciplines;
- technology has become more international;
- spinoffs from military R&D are less prolific.

Past strengths of the U.S. included its: attention to education which supplied a highly skilled work force; a large domestic market which encouraged investment in economies of scale; and strong domestic competition as a result of antitrust legislation and entrepreneurial spirit.

Successful policies of the past have been associated with industry consensus mechanisms which enabled the private sector to prescribe an appropriate government role for that particular industry. The Task Force notes that policy initiatives that are not mindful of the attributes of specific sectors may introduce undesireable results. For this reason, policy should be developed with a sensitivity to the nature of the specific industry or sector in question, and mindful of impacts to other sectors.

B. THE ROLE OF THE FEDERAL GOVERNMENT

The role of the Federal Government was discussed and the question of what forms of technology should receive federal support was asked?

In addressing the Federal Governments proper role in efforts to improve the technological component of the nation's economic performance, Dr. Branscomb stated,

"Any such policy, it seems to me, has to satisfy two conditions. First, it has to be technologically realistic, and it must be able to address how firms in other countries compete successfully with ours without having either of the fundamental science or the innovation capabilities for which this nation is justifiably renown.

"In other words, it must recognize the pivotal importance of downstream science and engineering activities which have, in fact, provided others with a cost base and a quality level that has caught many of our companies by surprise.

"The second requirement for such a policy is that it must avoid the valid objections of what most people mean when they say Federal industrial policy. That is, it must not put Federal agency officials in the position of second guessing business judgements that are best made in a highly decentralized competitive environment responsive to fast changing competition and market conditons."

Furthermore, Dr. Branscomb noted that the linear model, of innovation development is in error. "This model assumes innovation development is comprised of numerous functional steps, each step becoming more

application dependent and this reasoning results in the conclusion that government should fund only basic research."

However, Dr. Branscomb notes that most downstream engineering evidences a mixture of work, "some of which is very narrow and application specific and some of which is very general and can be widely shared." In response to Dr. Nelson's concern over what has changed, Dr. Branscomb notes that "What is different is that engineering has become scientific. It has been codified."

Examples, cited by Dr. Branscomb, of downstream technologies that are the fruits of research but do not receive the requisite support from Federal science agencies include: "automated design for manufacturability; manufacturing systems engineering; quality testing and process control; materials handling and distribution; and information systems support for balancing organizational control and efficiency with decentralized creative decision making."

The practice of Federal support of only basic research is very limited and may preclude important research in generically applicable, yet application related technologies. Research investments in such application related generic technologies are of great importance to the national interest.

C. MANAGEMENT OF FEDERAL R&D

One of the issues being considered by the Technology Policy Task Force pertained to ways in which the Federal Government might improve the management of their research and development programs.

A significant discussion ensued regarding the need for, and scope of, an organizational infrastructure, within the Federal Government, for policy implementation. Chairman MacKay posed the issue as follows:

"The U.S., ... seems to have an infrastructure that is based on the idea of a number of islands. We have universities doing their thing. We have federal labs that are in all kinds of illogical places."

I want to ask ... would it not make more sense for us to organize the Federal Government rationally [if that] would help with the problem? ... Wouldn't it make more sense for us to do like the Japanese...?"

Dr. Nelson responded: "By the way, my understanding of the effectiveness of the MITI structure is not incompatible with the observation that Lew Branscomb made some time earlier. While that structure certainly played a very important role during a certain period of time in Japanese post World War II development, there is an awful lot of mythology that has been built up ascribing to MITI credit for a whole bunch of other things, for many things that might be better described as

other factors in Japan like the enormously high investment rate, like the tremendous investments in education that the Japanese have engaged in and so on.

To return to your question about organization of infrastructure and organization of policy bearing on industry, ... history over the last 20 years or so suggests that it is a very difficult question to wrestle with. That is not an argument for not continuing to wrestle with it and doing better on it."

Dr. Branscomb then offered the following comments:

"In many respects it is probably better to proceed down that pragmatic path of inventing the thing you have to have to do the job at hand and kind of letting the future take care of itself.

What is missing in that strategy, in what Dick Nelson has just been speaking to, which I think is the most important thing to happen, that is for the Executive Office of the President to take seriously their management responsibilities for R&D.

Dr. Branscomb continued: Here we have a government which is spending some $67 billion dollars a year in R&D and is leveraging the other $70 billion of private R&D through the government's regulatory actions and behavior in the marketplace. Yet for the last two administrations,

this is not a political party label failing, both the last two Presidents, that is, Mr. Reagan and Mr. Carter, didn't get around to appointing a science advisor and a director of OSTP until the middle of the spring, after every other job had been picked, after the White House staff was completely locked up. Hence, there was no bargaining power available for the candidate to negotiate with the chief of staff or with the President about what his relationships might be with White House offices, with OMB, and with the Cabinet offices.

So if I could change one thing, it would be to persuade every political candidate of both parties to pledge that they will have a designee for the science and technology special assistant to the President before the first of January or at least before the 21st of January, I guess, when they take office.

Secondly, I do think some structural attention to OSTP is needed and again I don't know that you can force that on a President. Even though it is a legislative body, a creature of the Congress, indeed of this Committee, and yet it seems to me that OSTP must be given some direct capability and responsibility for extending their scope into the economic dimension of what they are all about.

Other people writing on this subject have from time to time made many suggestions. Pat Hagerty suggested a kind of joint OSTP and Council of Economic Advisors operation. Ed David has suggested a few years

ago in print that the science advisor should be given some formal assigned responsibilities with respect to the program evaluation function at OMB.

I think there are a variety of things of that kind, worthy of exploration. If we had a strong OSTP and I believe today it is weaker than it has been for a long time, then we at least have an instrumentality capable of focusing the debate on the defense/civil trade-offs and on trying to find organizational options that fit the personalities and the current political situation and the art of the possible."

Mr. Sumney concurred with these remarks, while noting the potential for a National Advisory Committee, comprised of people who "... reflect the cross-sections of the components in our infrastructure and over time. If it is successful, perhaps authority can evolve into other areas, but I do not think that it needs to have financial control at the beginning, that it would be an advice/guidance coordination function. But I think it would greatly serve to make things more efficient and operate more smoothly."

Concurring with the perceived need for organization adjustment for implementing technology policy, Mr. Seifert responded:

" One thing we have learned in industry is that we have had a lot of missions and policies and goals, but we didn't put something in place that had the ability to make it happen and carry out this policy

and we got ourselves into trouble.I don't know where it should be positioned but there needs to be some kind of an oversight board to see that it happens."

Chairman MacKay pressed the need for greater coordination by suggesting the trade-offs that may take place in R&D. He stated,

"Here is my thesis. We are about to get into a situation where the amount of money available for science and technology and basic research and development in government is going to be very, very limited. We are not going to have the luxury of deciding we want to do a super collider without figuring out where the money is coming from.

It is going to get to be zero sum. We are going to have to, in order to do something else, cut out something. Can we afford to continue the luxury of national labs scattered all over everywhere without an oversight mechanism in the government, without a coordination or peer review, some of whom seem to have outgrown their existing or original mandate, some of whom are engaged in fine public sector entrepreneurial activity of getting out and looking for something to do that has money attached to it?

Can we afford that and if we can't, how do they fit into this idea of a decentralized decision making process but still give us a chance to get the most bang for our buck? "

Both Dr. Branscomb and Dr. Nelson responded that coordination was required and that this function was best located in the Executive Office of the President. Dr. Nelson further noted that we can no longer afford "the luxury of an Office of the Presidents Science Advisor ... disjoined from the Council of Economic Advisors or the Office of Management and Budget."

Mr. Sumney also reiterated the need for a national oversight function as in an oversight board. He further stated that: "we need to coordinate all of our national programs more closely in order to make the best uses of the limited resources which are available such as our foreign competitors are doing."

Such oversight boards and consortia provide sectorally specific consensus instruments for pursuing policy issues.

A suggestion by Dr. Branscomb for facilitating the movement of Federal Government resources to more urgent technology issues follows:

"It is something that the French government either does or in any case did. When Pierre Aigram was the director general of research and technology in French government, he had the authority to deploy a piece of one of the CNRS laboratories on a problem that he concluded was urgent and there were funds available, allocated for his control to fund that work and the only requirement was that within three years of its initiation he had to have line item support from the legislative

branch in order to continue with it, but he could start without asking for it.

It seems to me that if we had a strong OSTP and they had the authority to direct the Department of Energy to deploy ten percent of the budget of those national laboratories on a problem that the National Science Advisor and the President agree is urgent, that they be able to deploy that manpower subject again to coming back to the Congress to validate the project they have undertaken through their legislative process and appropriations process which, as you well know, takes a couple of years to get into and back out of again, that would be just one mechanism for trying to address the issue you described."

All of the witnesses concurred with the thesis that U.S. national R&D programs require greater coordination in order to make the best use of our limited resources. The witnesses also suggested that the lead in this effort should rest with the Executive Branch. Specifically, a stronger presence by the OSTP could facilitate coordination among agencies, the Council of Economic Advisors and Industry. The development of sectorally specific private sector consensus mechanisms has the potential for focusing Federal Government R&D, in concert with commercial needs. Hence a strengthened OSTP and industry advisory councils patterned after the NACA may be important next steps.

The witnesses emphasized the strength of the U.S. decentralized decision making process which enables the private sector to rapidly respond to market forces.

D. THE ROLE OF UNIVERSITIES AND ENGINEERING RESEARCH CENTERS

Congressman Packard opened the discussion on the role of the universities by asking,

"What would be an appropriate role or a role which we now do not take in our university systems in the competitiveness issue?"

Dr. Nelson responded by saying, "There are two different kinds of roles that currently are becoming more prominent. One of these is concerned exactly with some of the questions I think we are going to get to later on this morning and that is the appropriate roles of universities as loci of research in interacting with companies in cooperative and joint ventures.

Where does the university line and research end and where does the company line end and begin and what is the appropriate mode of interactions between the two, the engineering research centers being one experimental probe at some new institutions there?

The other aspect of the matter that you are questioning about relates it seems to me to the kind of research and teaching that goes on at universities that are concerned with the nature of U.S. competitive problems and sort of analyzing the problem as contrasted with participating with industry in forging a solution.

I see in many places the development of many more courses concerned with trying to comprehend the matter, an increase in research and writing in a number of fields concerned with this."

The general consensus of opinion indicated that universities should provide a loci for research, interacting with corporations, joint ventures and government labs. Universities should seek industry cooperation in structuring curricula which provides highly skilled professionals to the private sector.

The question then concerned the extent to which the Federal Government should attempt to encourage cooperation among various universities, private industry and the government laboratories.

In an effort to assess whether the Federal Government should facilitate university, industry and government cooperative efforts, Congressman Packard asked, "Mr. Seifert, you spoke to that issue a little bit. Do you think this process of more cooperative efforts between government and industry will come about naturally or do you believe there should be some government role to encourage it or do you think that industry needs to do more?"

Mr. Seifert's response was, "Let me, if I may first comment, we counted 30 major initiaties in universities on manufacturing, somehow associated with universities either through separate corporations or actually within a university. In most of those initiatives, the industry has been contacted for support and is supporting.

Those initiatives are focused on the technical side, on the research or the applied engineering. There were very few initiatives which link up what you call the marketing side. There have been some traditional schools, like the Sloan School, that do a very good job of that. I think that is the situation.

I think it has to be a joint industrial, academic and government supported program. It is not just the funding but the expertise. The universities sorely need experienced people from industry. We are moving a lot of people on part time, not ony teaching courses but into these programs. We have the usual problems of competing for salaries because industry pays a little better but I think it has to be a three-way street.

I think the government needs to stimulate this and someone mentioned create the environment whereby this is an important national initiative. One of the ways we do it is by funding the research that tells these schools that is important."

In an effort to facilitate university and industry cooperation, Dr. Branscomb noted that the government should finance joint research work in downstream technologies. He recommended that the:

"Commerce Department have the capability to finance joint work between industry and universities in this case in the downstream technologies. I don't believe we should be dependent entirely on the National

Science Foundation for supporting the intellectual work and the education base at the post graduate level for advanced manufacturing systems and processes and the like. In fact, if you look very hard at the engineering research centers, they are all quite well chosen and doing excellent work but it is still not quite far down that spectrum, downstream spectrum, as makes sense."

It would seem reasonable that the Federal Government should encourage university, industry, and government cooperation via its funding mechanisms in NSF (such as the engineering research centers) and extending the ability of the Department of Commerce to fund joint (downstream) technology research.

The hearing shifted to the issue of possible deficiencies in university training that could potentially lead to a lack of ability to compete in the world market.

Congressman Packard asked, "In our institutions, in our universities, do we have courses in our curriculums specifically designed to instruct people or students in manufacturing, in product development. I know we do in marketing, but do we in product development?"

Dr. Nelson responded that the level of joint engineering and business trianing is not sufficient. He stated:

"It is my belief that there is much less interaction and joint work and joint training between American engineering schools and American

business schools than there ought to be. In most campuses that I know about, these are two shops on their own bottom and there is not much in the way of training of young engineers to become managers. Many of them, the best of them, soon will become and on the other hand, the business school training often and in most cases does not dip into giving those students an appreciation of technology or technical change or the management of the research function or the interaction between research and manufacturing that it ought to. I think this is unfortunate."

E. THE ROLE OF COOPERATIVE INDUSTRIAL AGREEMENTS

One concern of the Task Force has been the semiconductors are basic to many commerical and defense technologies. However, advances by the Japanese semiconductor manufacturers in high volume technology drivers, such as memory chips, has severely threatened U.S. industry. Hence the Japanese long term strategic application of technology policy has encouraged U.S. semiconductor producers to directly confront the challenge.

Mr. Sumney observed that, "By the mid 1970's, U.S. semiconductor firms recognized that they indeed confronted a formidable competitive challenge which could not be met by individual companies acting alone, no matter how innovative and how efficient they might be. U.S. semiconductor producers concluded that in order to confront such a challenge directly, they needed to engage in a greater degree of collaboration and to work more closely with the U.S. Government."

Describing the forms of cooperation embraced by the semiconductor producers, Mr. Sumney noted,

"One of the first manifestations of this new spirit of cooperation was the formation of the [Semiconductor Research Corporation] SRC, which was created in 1982. Its principal objective was to fund basic microeletronics-related R&D in the university system in this country reflecting the fact that a decreasing amount of university research effort was being placed on fundamental R&D for industrial use.

The SEMATECH mission very succinctly stated is to reverse the erosion of U.S. leadership position in manufacturing technology. Its objectives are to develop future generation semiconductor manufacturing processes, materials, tools and test equipment, prove and demonstrate them, and then transfer that knowledge which is the real product of SEMATECH to member companies.

SEMATECH will take research results coming out of the SRC and translate them directly into reality. It will be done generically rather than on a company-by-company basis which is much more costly and results in inefficient duplication of effort. The results coming out of SEMATECH will then be diffused industrywide."

Furthermore, in terms of cooperating with universities and national laboratories, Mr. Sumney stated that, "SEMATECH will sponsor research activity to complement its development efforts. The SEMATECH operating

plan calls for the SRC to provide the interface between SEMATECH and the research community with which the SRC already has begun to establish a very close working relationship.

This includes not only the universities but our national laboratories, government research entities and the independent research efforts in semiconductor technology such as those funded by state governments.

As a part of this effort, I am chairing a steering group examining the potential for a National Laboratories Initiative in semiconductors. In its research role, SRC will perform assigned research tasks for SEMATECH, create a knowledge base in areas of future manufactuing development and address issues associated with education and with training."

With regard to government support, Mr. Sumney noted that industry has agreed to raise half of the required $250 million dollar cost of the SEMATECH effort over a five year period. He further observed that foreign governments are well acquainted with government supported consortia. He stated that,

"Virtually every industrialized and developing nation which has sought to accelerate the development of a national capability in microelectronics has utilized the R&D consortium funded both by government and industry as a principal vehicle. Such entities eliminate duplication in R&D, speed up development, and most importantly ensure a wider diffusion of research results throughout industry. SEMATECH is

intended to secure all of these benefits for U.S. industry. However, it will differ from many foreign consortia in one respect. It will encourage, rather than restrict, participation of small companies. SEMATECH will give such firms access to R&D results far greater than they could ever achieve through their own efforts and in so doing, will help smaller innovative firms, which have always been an important U.S. asset, to remain viable contenders."

Mr. Sumney also emphasized that these consortia are necessary but do not represent a complete strategy. He recommended a further addition to the technology infrastructure, that is, a National Advisory Committee on Semiconductors. The purpose of this organization would be to provide oversight, and "overall leadership and direction for SEMATECH to cooperatively provide essential development of semiconductor manufacturing know-how."

The SEMATECH proposal compliments the semiconductor research of the SRC by focusing on technologies for manufacture. The high cost of R&D and foreign competition in the industry has necessitated some form of industry aggregation. Consortia such as SEMATECH and the SRC, coupled with a National Advisory Board, provide an industry consensus instrument coordinating programs and policy. This mechanism may also be useful in assisting the evolution of our Mission agencies.

Congressman Packard questioned the witnesses on the role of consortia in the U.S. He noted that the Japanese and other foreign nations had exploited such cooperative arrangements and asked, "We are

developing in some isolated circumstances here in this country consortium of industries in an effort to perhaps duplicate in the private sector some of the same things. Do you see that becoming more and more of a need, more and more of a trend and, if so, how will that affect small business competitors with these large consortium of businesses?

Dr. Branscomb responded by describing the essential value of such consortia. He stated, "However, I believe that those consortia are very important and that they might be even more important here than in Japan because this country needs a way to find a legally permitted method for the self-selected voluntary participants in an industry to say that we have a common set of technical problems, we have an instrumentality to discuss them in enough technical depth to get below the superficial level of advocating tax credits or whatever is easy for everybody to do without study and out of that might come the consensus we are all waiting... So I really do believe that we need an industry consensus mechanism and it has to be sectorally specific."

Congressman Packard also probed the witnesses with regard to the similarities and differences between the microelectronics industry difficulties and those of steel and automotive. He asked, "Are there characteristically similar patterns in the troubles of the microchip industry and these other industries and what does that say in terms of the free enterprise system versus the government sponsored and government subsidized systems in some of our competing nations?"

Mr. Sumney responded by observing that the U.S. microchip industry has maintained a preeminent design capability by devoting significant portions of their sales revenue to R&D, higher than any other industry sector. However, he stated that, "Because of things outside of their control such as the dumping problem, they have fallen behind in the ability to competitively manufacture technology drivers, very high volume products, and recognizing that, they feel and I think rightfully so, that perhaps the only way that they can recover in time the ability to manufacture competitively is through a consortium."

Noting the entrepreneurial and fragmented evolution of the semiconductor industry, Dr. Branscomb added, "So to some extent, the problem our industry faces in my personal opinion is the need for some industrial aggregation or sharing or partnership, some mechanism to pool the process technology interests of these large numbers of firms."

Dr. Nelson reiterated Dr. Branscomb's concern over industry aggregation when he said, "Most of the issues that Larry Sumney has been talking about in the proposals that he has mentioned are associated with the fact that while there are some giants in the industry like IBM and AT&T, this is a quite fragmented industry and there is not much in the way of upstream/downstream integration. Indeed, I take it that SEMATECH is concerned very much just with that fact."

Dr. Nelson also noted that the automobile industry, with significant upstream/downstream integration experienced problems due to the

complacency in giantism. Hence, he underscored his assertion on technology policy being sectorally specific when he said, " You are not going to hear SEMATECH from the automobile industry. You may hear something else but not that."

The Semiconductor industries have invested considerably in R&D, unlike other industries in decline. The costs of R&D in this sector, the fragmented entrepreneurial evolution of the industry, and targeted foreign competition have required further industry aggregation. The SEMATECH consortium is both an example and experiment. It has provided a sectorally specific consensus mechanism in its quest for assistance.

This also raises the question of how the national laboratories might contribute to the strengthening of industries in the semiconductor as well as other industries.

On the issue of national laboratories and mission agency support of the SEMATECH proposal, specifically, Mr. Sumney stated that, "I have been working with the National Academy of Sciences and Engineering in putting together a series of workshops. We have held two of them between the National Laboratories and the Semiconductor Industry and out of that we have come up with what you might call 20 mini-proposals that match indeed the capabilities and interests of the laboratories with the needs of the semiconductor industry.

The next step is what do we do with this and Lew Branscomb's ideas are, I think, exactly what we are going to try to do. It is going to

have to encompass a change in mission by the Department of Energy to allow the laboratories to do this.

Our approach at the moment is to have Frank Press write a letter to the head of Energy recommending that this be done. We have also worked with OSTP in the forumlation of these recommendations and also we are thinking about the recommendation he just mentioned that OSTP would direct such a move."

A careful review of proposed mission changes for the national laboratories may be required.

F. GOVERNMENT PROCUREMENT

The question of government influence was brought up by Congressman Packard who wondered if the Federal Government demphasized commercial development of technologies through the pursuit of inappropriate missions.

Congressman Packard expressed concern over the pursuit by U.S. industry of the military market, perhaps to the demise of commercial markets. He remarked that the defense related market place in this country is a predominant marketplace and "contractual arrangements often are the easier way for them to market their product and in doing so I seem to feel that they may have shied away or in some cases almost

abandoned the non-defense related marketplace to our foreign competitors. Is that so and if so, what should be done to change that because we still find in this country a strong Defense oriented marketplace?"

Mr. Sumney responded by saying, "The status of the semiconductor industry in the United States has changed drastically over the last five to ten years. When I started the VHSIC program in the late 1970's, the goal of the program at that time was to structure a program where DOD could address its integrated circuit needs based on the strength and the leadership of the commercial sector. In order to do that, we structured a program that would foster the teaming between commercial companies and aerospace companies. An example at the time was Motorola teaming with TRW and in the time since, that has been broadened to include Honeywell as well.

What we saw as the program progressed is that the teaming arrangements that were established did indeed work but because of things that we have already mentioned here today such as dumping, the commercial sector started to lose some of its strength.

What we see now is that if the investment that this country has put into the VHSIC program which is nearly a billion dollars in R&D is to receive maximum utilization, the commercial sector is going to have to regain its strengths in manufacturability for a number of reasons, one of which is to support the infrastructure which the aerospace companies

depend upon just as the commercial companies do for equipment to manufacture their product."

Dr. Branscomb added, "But over a perspective of more like 20 years, I think, the predominant trend has been opposite to the one that you suggest, Mr. Packard, in the following sense. First of all, when I was director of the Bureau of Standards, the government was buying about 14 percent of the general purpose computers made in this country and it is now down to somewhere in the eight percent range...

In any case, both in purchases of electronics and of computers, the government has been a small and declining segment of the U.S. commercial market. In fact, that has led to the fact that a fair number of commercial companies are not interested in taking bids from the Defense Department for product for a variety of reasons...

So I think one of the important areas of policy work that needs study is the question of to what extent might the Defense Department itself achieve its own mission more cheaply and more quickly and with better technology modernization if it found a way to work with the commercial industry more directly rather than the curent pattern of working with companies that are specifically set up to do business with the Defense Department."

It is not clear as to whether Government Procurement has caused a deemphasis in the pursuit of commerical markets. However, the Federal

Government should try to choose technologies which compliment private sector products and technologies when such a procedure would not compromise the effectiveness of defense products.

G. SELECTED TOPICS ON THE PRIVATE SECTOR

1. Enhancement of the U.S. Manufacturing Enterprise

Mr. Lawrence Seifert gave an overview of the strengths and needs of the manufacturing industry in the U.S. He cited several strengths: "First let me say that we have experience with work forces in other countries and we believe the American work force in manufacturing is as good as any in the world. Other countries are coming up but that is not a problem. It is highly trained and highly motivated.

Secondly, we have a very strong technology base. We have some weaknesses in semiconductors because of initiatives in other countries and I think Mr. Sumney explained that very well but we do have a strength in software which is generally far superior to anything else in any other country. The application of computer tools and software technology to the manufacturing engineering job has given us the most leverage. We have actually been able to overhaul U.S. factories and make them competitive without the application of a lot of hardware automation."

Mr. Seifert described the needs of our manufacturing base as, "First, we need to maintain and strengthen our technology base. Secondly, our problem has been the application of this technology

across our factories and that is the area we need to focus on. Lastly, it is getting very expensive to overhaul and upgrade and apply all of this technology in factories and we believe we need free access to other markets to give us the base to afford that application of technology."

The need for continually upgrading our education system, especially univerisity programs for manufacturing and the establishment of manufacturing as a national priority were found to be essential by the entire panel.

Mr. Seifert commented on the application of technology and the lessons learned by observing that,"

-- The key we have found in manufacturing is to overhaul our manufacturing systems in a way that would do the job differently. There is a lot of waste. There has been a lot of poor quality. We waste a lot of time as well as material.

-- Factories are places where there is an awful lot of information flowing around and we have concentrated the application of computer technology to our factories. We deal with an awful lot of sophisticated ordering systems, billing systems, product configuration software and that software is giving us a lot of leverage in doing the job much faster.

-- As it relates to physical automation, we don't believe the key is automation where we directly replace people with robots, or that kind of automation. The key to robotics and that kind of technology is to do things that people can't do."

According to the witnesses: U.S. manufacturing strengths lie in our technology base, educational system, and software capability. The application of U.S. computer and software technology should provide us with the greatest leverage. The work force is competitive. Nonetheless, to date industry has had difficulty in applying the appropriate technology, in part due to the extensive costs of factory renewal.

It appears that performance improvements in manufacturing should become a national priority while academic institutions upgrade curricula for manufacturing and industrial management.

Congressman Henry explored the potential for automation in addressing competitiveness problems by asking if we "will get to a point of such automation in the manufacturing process that the labor cost differentials that we have will be offset by the transportation cost differentials of overseas countries?"

Mr. Seifert responded by saying, "It is possible that the manufacturing labor in many assembly operations is far less that the transportation costs. However, you need to understand that these countries

are bringing up their white collar labor to our level and their engineers and scientists also are far less expensive than ours and there is a lot of engineering effort that goes into those kinds of factories. So it is not just the traditional labor, but it has been the new labor, the engineering and scientific labor and that can go off shore as well if we are not careful."

Dr. Branscomb added: "To me, the key issue in this whole downstream engineering is not the amount of labor required to assemble and test the products in the factory. That can be reduced to low levels in most mechanical assembly situations to the point where having a factory with no light switches is irrelevant. A few people in there doesn't add anything to the cost.

The real issue is all of those engineers and indirect personnel that people don't show you when they take you on a walk through their automated factories, they are in another building somewhere, but they are responsible for keeping all this system running and they are expensive."

The Task Force continued searching for the barriers to manufacturing competitiveness. Congressman Henry, asked, "What are the key roadblocks, right now, other than tax credits?"

Dr. Branscomb suggested the following impediments: "I believe, first of all, the principal impediments to U.S. competitiveness can be found here in the United States. You don't have to go abroad to find

them although if you go abroad, you will see some things that will tell you where to look.

I believe they are lack of focus on the technological possibilities and strategies to fulfill them by senior industrial management, the failure of this country to accord importance and prestige to the manufacturing function which has many indirect consequences both in the firm and in education, the failure to capitalize our workers with modern tools which gets back to the savings rates and the macroeconomic problems and the improving but as yet, I think, unsatisfactory level of information diffusion between the knowledge generating sector in our society and a very large group of those who most need it; namely, the firms that are smaller than a billin dollars a year in gross sales which is roughly the level at which you do or don't have a corporate research laboratory."

Congressman Henry noted that two of the cited problems involved changing attitudes and technology transfer.

Dr. Branscomb added, however, "I don't believe there is any way that Congress either can or should attempt to legislate the attitudes of Americans. What the Congress can do is in certain circumstances to alter the environment within which Americans make decisions."

These themes, posed by Dr. Branscomb, and the other witnesses addressed the questions of: Where do we go from here?; and What is the role of the Federal Government?

a. Research - All of the witnesses encouraged increased Federal support of research. Moreover, the panel believed that generic research, which may be more closely tied to an application or industry than basic research, should receive Federal Government support. Examples of these technologies cited by Dr. Branscomb, included: automated design for manufacturability, manufacturing systems engineering, quality testing and process control, materials handling and distribution, information system support for balancing organizational control and efficiency with decentralized creative decision making.

b. Technological focus and consensus -Dr. Branscomb noted the need for senior industrial management to focus on technology possibilities and strategies. When problems require cooperation of firms, government and universities, sector specific consensus mechanisms are necessary.

c. Education and knowledge transfer - All of the participants agreed that manufacturing is a national priority, albeit, U.S. universities and industry management have not embraced this perception until recently. All of the witnesses encouraged greater education emphasis on manufacturing technologies in both engineering and business university curricula. Dr. Nelson also suggested broadening the training of engineers via business courses. Most important was the enticement of top engineering talent to the problems in manufacturing by according greater prestige and importance to manufacturing. Mr. Seifert suggested: "One of the ways we do it is by funding the research that tells these schools that is important that they work on this."

In his written testimony, Dr. Branscomb suggested a major fellowship program is needed to attract American students to manufacturing and related engineering careers. Also he cited the need for university funding for equipment procurement.

Furthermore, Dr. Branscomb noted the need for building a greater manufacturing support capability, knowledgeable consultants and resource contacts, to assist smaller firms in advancing their technology manufacturing base. In addition to education, he said:

:

"Secondly, I would ask the Commerce Department to engage a major dialogue with manufacturing industry smaller than those that have corporate central research laboratories. These companies don't know how to relate, some of them relate well to universities where there is an engineering college that is local and they have a relationship, but by in large, the engineering colleges are staffed and funded for their research working in problems of limited interest to these companies.

I feel that if the Commerce Department began to build mostly out there in the universities and non-profits and even profit-seeking enterprises the kind of engineering support capability the country needs, then you could imagine the states coming to the Federal Government with a state technical services kind of mode and requesting technical expertise out of the Federal program for local industry development and job enhancement activities with the states.

The states are where the industrial strategy and partnership seems to be easiest to get going. The problem is that they don't have the intellectual resources to match it.

The witnesses also noted the need for factory renewals and greater capitalization of equipment for each worker. Macroeconomic conditions resulting in relatively high costs of capital and the necessity to prove investments on a short term basis were cited as major impediments. In short, the economic environment is not at all conducive to the very necessary and increasingly costly updating of the manufacturing enterprise.

Specific suggestions addressing these concerns included maintenance and/or furtherance of R&D tax credits, shorter tax depreciation schedules and tax credits for factory renewal. Responding to the concern of creating a conducive environment and difficulty with long term capital investment, subject to short term capital investment alternatives, Dr. Branscomb offered the following comment:

"I think corporate managements are pretty responsive to the environments within which they work and with the danger of a physicist starting to invent economics and I will quickly defer to Professor Nelson, I will give you one example of how I could conceive of persuading corporate management to take technology strategies more seriously."

"Why don't we tax capital gains at normal income rates for all capital gains made over a period of less than six months and why don't

we not tax capital gains at all for capital that is held five years with a sliding scale in between.

I don't know whether that is financially possible but I predict that it would have an immediate effect on the financial analysts of Wall Street when they look at strategies of companies whose stock they are evaluating."

Chairman MacKay pursued this concept by asking, " what if you worked upstream from that and said capital gains in effect, the part of the capital gain that is the churning of the market would be subjected to a surtax? Churning is the word. In other words, why don't we have a surtax on the quick in and out and then a normal tax at the six months level and then tapered down to nothing?"

The hearing participants concurred that further expertise was required in understanding the attributes of such a concept.

Congressman Brown also expressed concern over the value of the R&D tax credits. He said, "let me ask a specific question because I think Mr. Seifert you brought up the matter of permanent investment package, the R&D tax credit, and some question has been given to revamping the long term investment or capital gains situation, I have no evidence that either one of these has done a damn thing to improve our situation. Have you any indications that it has?"

Mr. Seifert responded, "I couldn't agree with you more. The issue here is not particularly just the technology issue but it is the linkage to the economic system. I am not sure that I know the answer. I know that it did affect our investments, losing investment tax credits on capital and it affected our ability to modernize as fast as we had been.

I don't have a sense of a macro sense of the industry. We have also lost market share worldwide during the same period so I am not sure which is the cause and which is the effect."

As addressed in this exchange and noted throughout the hearing, all of the witnesses and task force Members expressed concern over the need for decisionmaking that was sensitive to a tight coupling between technology and our economic system.

Research is esential for realizing manufacturing competitiveness. Research activity in downstream engineering should be supported by the Federal Government if it is generally applicable. U.S. corporate management must focus on technological strategies. Cooperative activity (universities, government and private firms) and the development of sectorally specific consensus mechanisms are important technology management opportunities. Manufacturing must be embraced as a national priority with academic institutions developing the requisite curricula choices. Emphasis may further be engendered by NSF funding choices, a national manufacturing fellowship program and enhanced university

equipment procurement. The application of technology to smaller businesses may be assisted via a dialogue between those enterprises and a Department of Commerce led network on manufacturing.

Factory renewal is essential although costs of capital and short term money management pose substantial barriers.

Measures to decrease the cost of capital, tax incentives and taxes on short term (churning) investments may provide a conducive environment for factory renewal.

Finally, economic policy must be tightly coupled with technology policy and impact.

2. Selected Issues in Communication and Computers

Communications and computer technologies are a major U.S. strength. Hence, the hearing concentrated on generic threats to the deployment and development of these technologies, such as the loss of semiconductor technology and the lack of a manufacturing enterprise.

However, several issues were addressed in Dr. Branscomb's written testimony, including:

1. the need for a computer literate citizenry;
2. enhanced GATT protection of services, software and the inherent intellectual property within the software;
3. encourage post-graduate training in software;
4. the evolution of standards must not be impeded by U.S. Government (DOD) procurement; and
5. the National Bureau of Standards should continue to support industry in their efforts to advance voluntary standards in communications.

Dr. Branscomb's testimony follows: "We must keep that advantage which calls for:

1. Continued attention to quality education for all our citizens, incorporating computers and other educational technology in imaginative ways. Every citizen must be not only linguistically literate, but most should be computer literate as well.

2. At the professional level, the growth segment of the computer industry is software. It is also the most profitable and the segment in which the U.S. industry has the largest margin of superiority internationally. To protect this lead we need GATT coverage of services and software and protection of the intellectual property inherent in software products.

On the educational side, the Federal Government should give serious attention to encouraging post-graduate training in software engineering. It is not clear that this is an area within the research scope of interest of NSF. It is at too high an educational level for Department of Labor. But professional skills in software engineering are the gating factor, in my opinion, in the ability of most companies to expand their beneficial use of computers. Yet computers hold the key to productivity growth.

3. Computer communications is the key to making a virtue out of the diversity born of the innovations encouraged by deregulation. Government should be sure it is not an impediment to the evolution of standards generated by the conjunction of interests of users and manufacturers. In point of fact there is a problem here: The Department of Defense continues to use protocols for digital packet switching (TCP-IP) which are different from those most accepted internationally (in the context of OSI and ISDN) and used commercially both here and abroad. The universities also make extensive use of TCP-IP, reflecting the influence of defense support of universities and the research contribution made by academic computer scientists to ARPANET and other defense network projects.

The National Bureau of Standards, on the other hand, works harmoniously with the manufacturers and users in industry not

only to advance voluntary technical standards for OSI but also some application-specific standards such as MAP, in which General Motors plays a leading role. NBS is serving the correct role in behalf of the Federal Government. The Defense Department should be urged to bring its standards into harmony with commercial ones, which will also facilitate defense utilization of readily available commercial products.